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**INTERNATIONAL SAINT JOHN RIVER
BACTERIOLOGICAL SURVEY
AUGUST / SEPTEMBER 1984**

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INTERNATIONAL SAINT JOHN RIVER

BACTERIOLOGICAL SURVEY

AUGUST/SEPTEMBER 1984

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Harold S. Bailey

Water Quality Branch

Atlantic Region

Moncton, N.B.

November 1985

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Dr. Paul E. Belliveau, Chairman
International Technical Advisory Subcommittee
on Water Quality in the Saint John River

Dear Dr. Belliveau:

The Water Quality Branch is pleased to transmit to you a report on the bacteriological survey conducted to determine compliance with revised water quality objectives developed by the International Technical Advisory Subcommittee. The data assessed was collected over a two-week period in August/September 1984.

The results from seventeen sites surveyed indicate that all of the international portion of the Saint John River is not in compliance with the Water Quality Objectives. The survey also concludes that the bacterial loading of the Saint John River by the tributaries of the upper basin was minimal. Also, there was no correlation found between fecal coliforms and major ions and nutrients analyzed during the survey.

Your subcommittee comments on this report and its recommendations for future studies are solicited.

Sincerely,

D. H. Cullen, Chief
Water Quality Branch

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ABSTRACT

Bacteriological and water chemistry samples from seventeen sites in the international portion of the Saint John River were analyzed for fecal coliforms, fecal streptococci, major ions and nutrients. Three Saint John River sites at Clair, Edmundston and below Edmundston exceeded both the average and maximum objectives. As in 1983, the FC/FS ratio indicates that the majority of bacterial input originates from poultry and farm animals. It was also found that the bacterial loading of small tributaries above Edmundston had little effect on the Saint John River. Also, there was no correlation found between fecal coliforms and major ions and nutrients during the survey.

RÉSUMÉ

Des échantillons d'eau ont été recueillis de dix-sept stations situées dans la partie internationale de la rivière Saint-Jean. Des analyses de coliformes et de streptocoques fécaux, d'ions majeurs et d'éléments nutritifs ont été effectuées sur ces échantillons d'eau. Les stations situées à Clair, à Edmundston et en aval d'Edmundston ont excédé les objectifs moyen et maximum. Tout comme en 1983, le rapport coliformes fécaux/streptocoques fécaux a indiqué que la majorité des sources de bactéries provenait des fermes d'animaux, en particulier d'élevage de volailles. De plus, il a été observé que la charge bactérienne des petits tributaires situés en amont d'Edmundston n'a qu'un faible effet sur la rivière Saint-Jean. Aussi, cette étude ne révèle aucune corrélation entre les coliformes fécaux et les ions majeurs ou les éléments nutritifs.

ACKNOWLEDGEMENTS

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1. INTRODUCTION

The bacteriological survey conducted during August/September, 1984, was the third Water Quality Branch yearly survey to monitor bacterial levels in the international portion of the Saint John River Basin.

The purpose was to measure fecal coliform levels and to compare them with the use-specific water quality objectives developed by the International Technical Advisory Subcommittee for waters of the Saint John River Basin. These objectives require that the fecal coliform limit (to protect swimmers) should not exceed the log mean of 200 organisms/100 mL and no single sample should exceed 1000/100 mL based on a minimum of five samples over a thirty day period (1).

In 1982, a bacteriological survey report (2) concluded that most of the seven sites sampled met the water quality objectives for swimming during dry summer periods. However during and after rain events the values at a number of sites increased more than tenfold and exceeded one or both of the water quality objectives for fecal coliform.

The 1983 survey plan adopted the 1982 report recommendations of increasing the number of sites on the main stem of the Saint John River and introducing a second bacteriological parameter, fecal streptococcus. The fecal coliform/fecal streptococcus ratio may be used to determine the origin of bacterial input (6). The results of that survey showed that two of ten sites exceeded the water quality objective

in 1983 (3). The rain events and resultant high values of 1982 did not occur during 1983, hence the data generated reflected only one regime - a dry period of relatively low flows. Eighty-six percent of the FC/FS ratios were less than 0.7 indicating that the principal source of bacterial input was of animal origin.

The 1983 report made two recommendations which were adopted in 1984. First, it recommended that a number of tributaries between the St. Francis River and Edmundston be included in the survey to determine their relative impact on the Saint John River. It also suggested that samples for major ions and nutrients be collected at the time of bacteriological sampling to determine if relationships exist between nutrients, major ions and bacteriological parameters.

2. METHODOLOGY

2.1 Sampling Program

Water samples for bacteriological analysis and chemical analyses were collected at seventeen sites in the international portion of the Saint John River Basin. A core of stations was retained from the 1982 and 1983 Surveys, with two new stations established on the main stem of the Saint John River and seven tributary sites established between St. Francis, Maine and Edmundston as recommended in the 1983 report.

The sampling sites are listed in Table 1 and their locations shown in Figure 1.

TABLE 1: SAMPLING SITES

Site #	NAQUADAT #	Site Description*
1	00NB01AD0032	Saint John River at St. Francis
2	00NB01AD0009	Little River at Hwy 205
3	00NB01AD0033	SJR above St. Francois de Madawaska
4	00NB01AD0035	Mill Stream, 2 km N of St. Francois de Madawaska
5	00NB01AD0036	Vasseur Brook at Hwy 205
6	00NB01AD0001	Saint John River at Clair
7	00NB01AD0037	Thompson Brook at Hwy, 0.5 km N of Clair
8	00NB01AD0038	Pelletier Brook at Hwy 205
9	00NB01AD0019	Baker Brook at Hwy 120
10	00NB01AD0039	Felix Martin Brook at Hwy 120
11	00NB01AD0008	Saint John River at Edmundston Inter. Bridge
12	00NB01AD0002	Madawaska R. at TCH bridge
13	00NB01AF0040	Saint John River below Edmundston
14	00NB01AF0021	Green River at WSC Gauge
15	00NB01AF0023	Grand River at TCH
16	00NB01AF0002	Saint John River at St. Leonard
17	01NB01AF0005	Saint John River at Grand Falls

* Complete descriptions are listed in the NAQUADAT Station Listing (4)

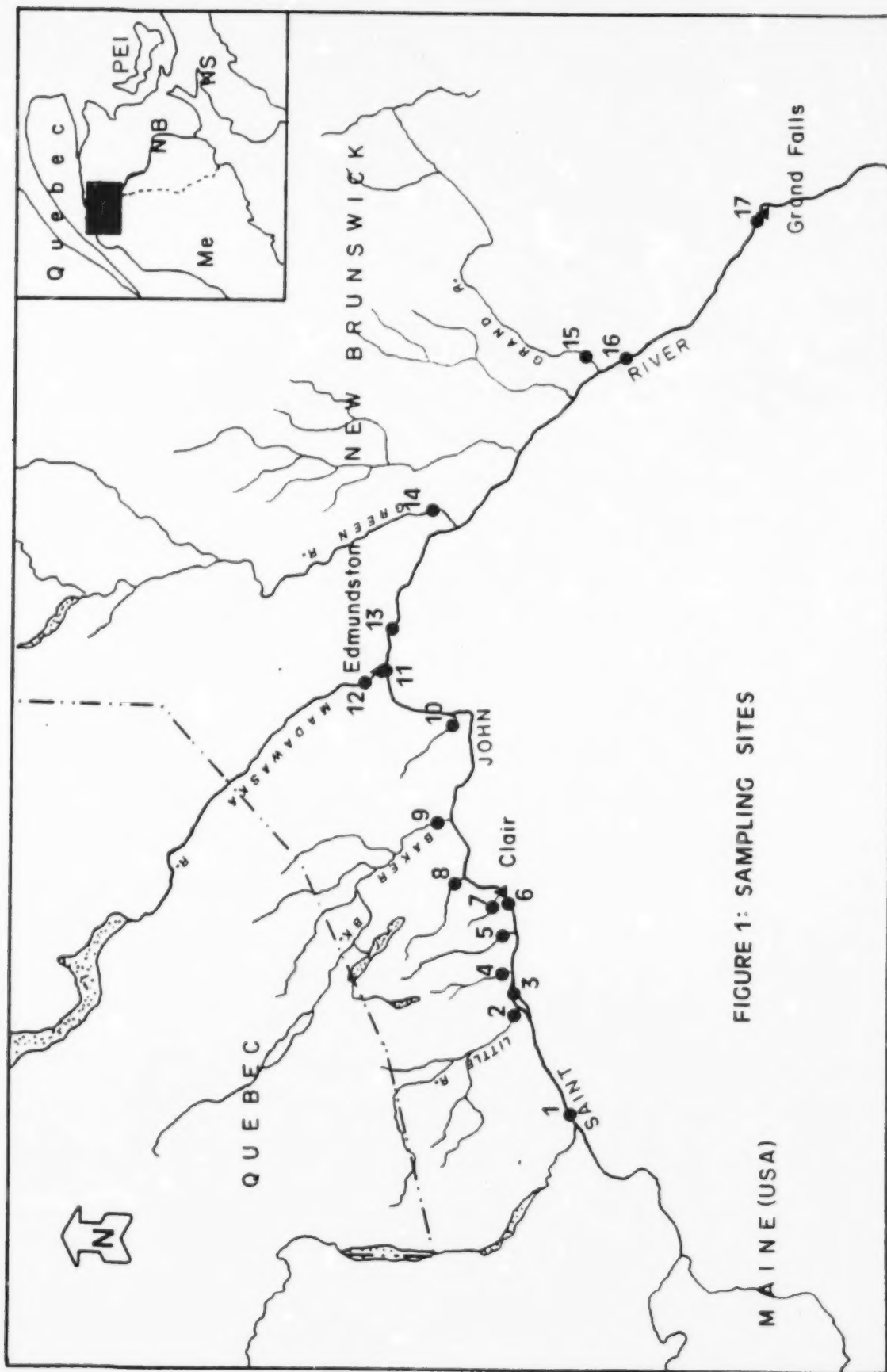


FIGURE 1: SAMPLING SITES

2.2 Field Methodology

Duplicate bacteriological samples were collected in 200 mL sterilized glass bottles 15-30 cm below the water surface, using a weighted iron sampler. Most samples were collected near mid-stream from bridges, however at a few sites, samples were collected by wading from shore. A one-liter polyethylene bottle for major ions and nutrients was also collected. Bacteriological samples were placed in a cooler at 4°C and delivered to a Water Quality Branch mobile laboratory in Edmundston. Samples were analyzed within two to four hours of collection. Samples for major ion and nutrient analyses were delivered to the Water Quality Branch Laboratory in Moncton.

2.3 Laboratory Methodology

The equipment and membrane filter procedure used for fecal coliform analysis is described in detail in a Millipore Ltd. publication (5). The methodology for fecal streptococci was as outlined in Millipore's Field Procedures in Water Microbiology AB314 (6). The stock media for fecal coliforms (MF-C broth) and fecal streptococci (KF Agar) were prepared according to manufacturer's instructions. Millipore HC membrane filters were used as they have been found to yield higher recoveries (7), and their pore design is better adapted to high turbidity waters.

For quality assurance purposes, controls were prepared by rinsing the funnel with three 20 mL volumes of sterile phosphate-buffered water.

The controls were incubated and counted with the samples.

Colonies were counted using a stereomicroscope (X20). The calculation of results was determined using guidelines from the U.S. Environmental Protection Agency (2,8).

The major ions and nutrients were analyzed according to established procedures described in the Water Quality Branch Analytical Methods Manual (9).

3. RESULTS AND DISCUSSION

3.1 The 1984 Survey Data and Compliance with the Water Quality Objectives

The 1984 survey philosophy considered two aspects - a compliance survey based on a "core" of 8 sampling sites to provide an overview of bacteriological conditions in the international portion of the Saint John River and, secondly, a survey to indicate the bacterial contribution of SJR tributaries above Edmundston.

Five of eight "core" sites and one of the two new sites on the main stem met the ITAS objective of five samples analyzed during a thirty day period (5). At sites sampled less than 5 times, such as the Saint John River below Edmundston (4 samples) and Green River (3 samples), the bacterial levels were well defined for a non-runoff period and additional sampling would not have contributed to the survey. Interference in fecal coliform analysis at the Saint John River sites at St. Leonard and Grand Falls also reduced the number of usable values. The tributary sites were sampled 3 to 4 times during the survey.

A detailed table of results, including fecal coliform, fecal streptococcus and fecal coliform/fecal streptococcus (FC/FS) ratio, is presented in Appendix I. The minimum, maximum, log mean values and compliance with the water quality objective for fecal coliforms at all sites are summarized in Table 2. The fecal coliform distribution (log mean) during the survey period is illustrated in Figure 2.

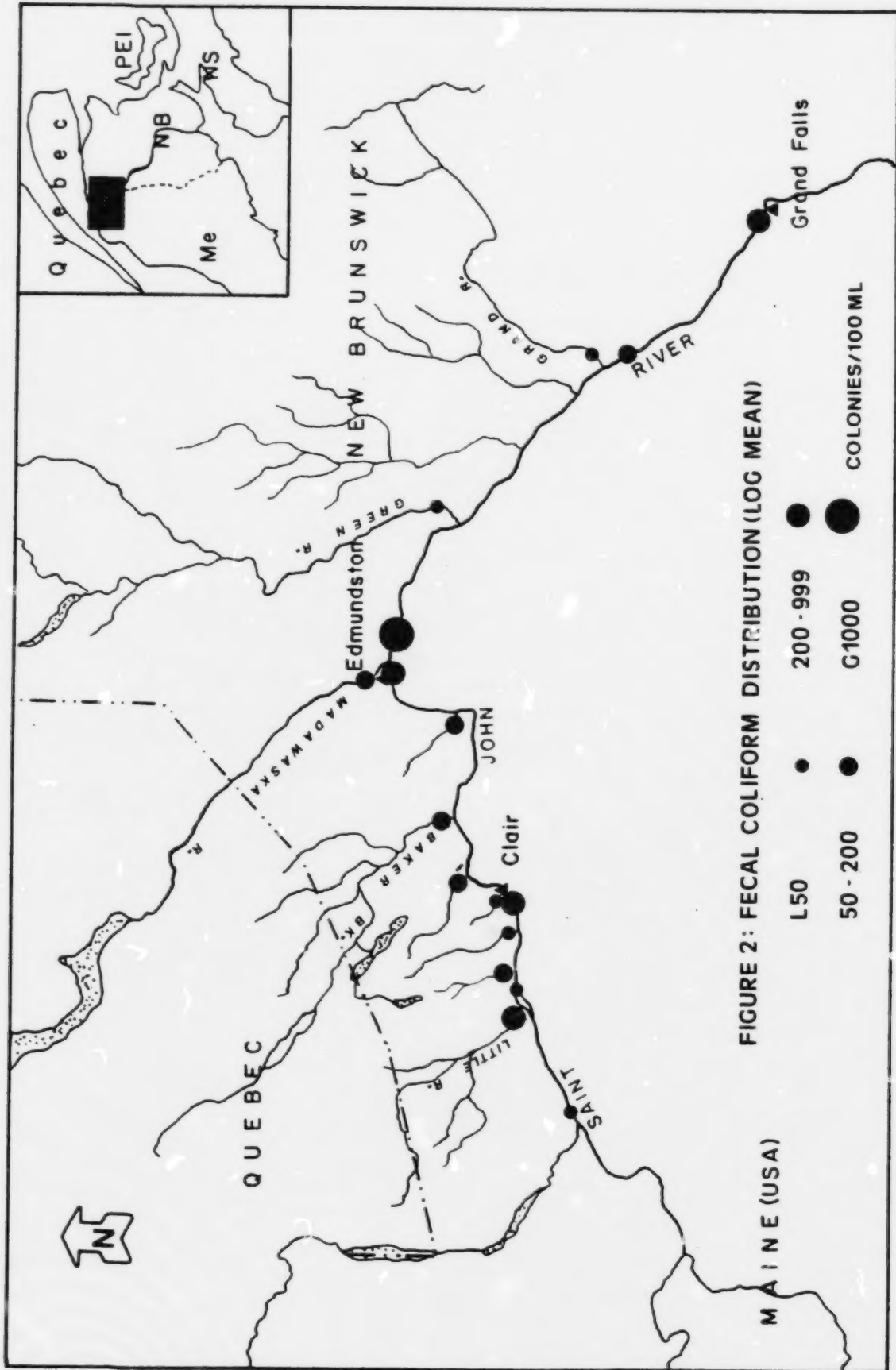
Table 2 shows that twelve of the seventeen sites met the water quality objectives for both average and maximum counts. Three sites on the main stem of the Saint John River - Clair, Edmundston and below Edmundston - exceeded both the average and maximum counts. Two additional sites which exceeded the average objective were Little River and Saint John River at Grand Falls.

TABLE 2: Fecal Coliform Data Summary versus the Water Quality Objectives

Station	Min.	Max.	Log Mean	# of values	Swimmable Objectives Met	
	per 100 mL				Max 1000/100mL	Average 200/100mL
1. SJR St. Francis	3	11	5	5	Yes	Yes
2. Little River	91	970	220	4	Yes	No
3. SJR above St. Francis	3	12	7	5	Yes	Yes
4. Mill Stream	19	270	74	3	Yes	Yes
5. Vasser Brook	7	15	10	3	Yes	Yes
6. SJR at Clair	170	1195	408	5	No(1)*	No
7. Thompson Brook	16	28	20	3	Yes	Yes
8. Pelletier Brook	40	390	90	3	Yes	Yes
9. Baker Brook	30	330	103	4	Yes	Yes
10. Felix Martin Brook	40	685	192	3	Yes	Yes
11. SJR @ Edmundston	150	1760	536	5	No(1)*	No
12. Madawaska River	120	190	161	3	Yes	Yes
13. SJR below Edmundston	7000	8700	7800	4	No(4)*	No
14. Green River	5	9	7	3	Yes	Yes
15. Grand River	18	100	35	5	Yes	Yes
16. SJR @ St Leonard	57	280	126	4	Yes	Yes
17. SJR at Grand Falls	140	750	324	2	Yes	No

* Number of times objectives exceeded

The Saint John River sites at Clair and twenty-two kilometers downstream at Edmundston exceeded the water quality objective for



average with log mean values of 410 and 540 colonies/100 mL respectively. Each site also exceeded the maximum once with values of 1195 and 1760 colonies/100 mL respectively. The high fecal coliform value at Clair on August 30 occurred during the lowest flow period whereas at Edmundston it occurred on a decreasing flow August 28. Figure 3 shows that there is no correlation between flow and fecal coliform at Edmundston or Clair. The figure does indicate that four of the five samplings were done during decreasing flows and one at low base flow. As discussed later, more positive correlations are expected when samples are collected on the increasing flows during and after a rain event.

The Saint John River site below Edmundston was located approximately 1.5 kilometers below the city. It was sampled from the Canadian side and although the river was deep and swift, streaming of domestic sewage was apparent, resulting in high values. These ranged from 6950 to 8700 colonies/100 mL, with a log mean of 7840 based on four samples. These results support the assumption suggested in the 1983 report that high values at St. Basile, 9 km downstream, may be attributed to domestic input at Edmundston.

The next site, some 35 km downstream of Edmundston at St. Leonard, had a much lower fecal coliform range of 57 to 280 colonies/100 mL and a log mean of 126. The low values are probably the result of natural die-off, less input in this rural area during dry weather and the high dilution factor of the Grand Falls headpond.

Little River, a tributary of the Saint John River situated

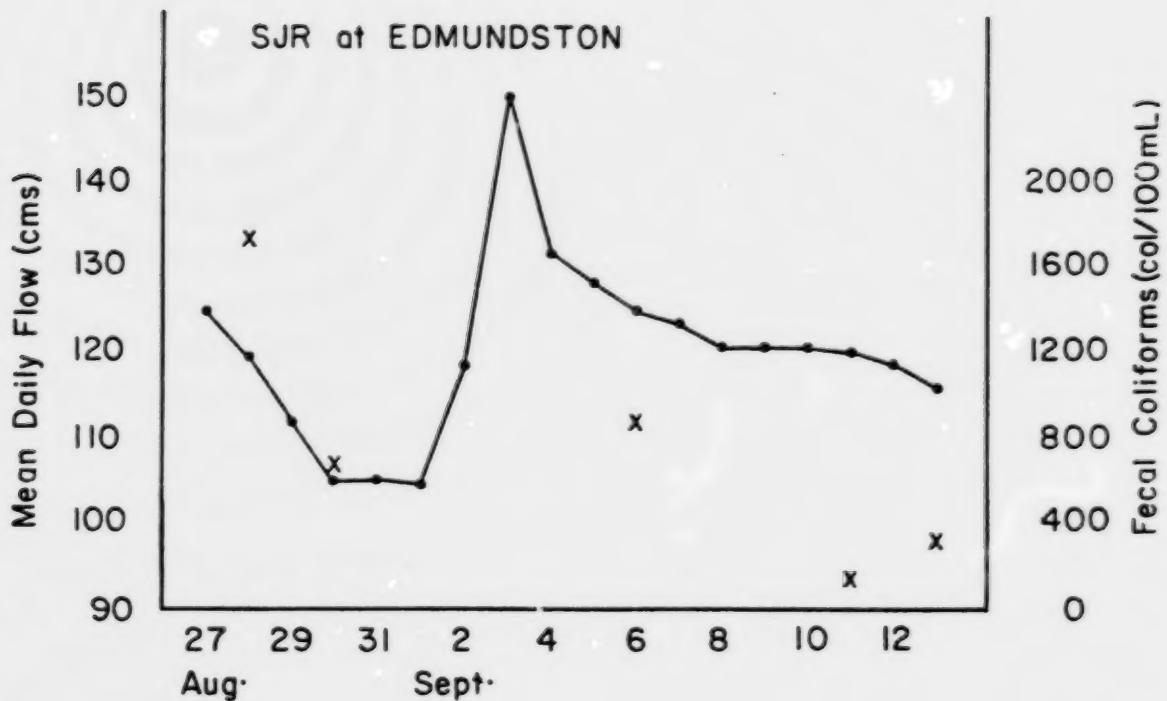
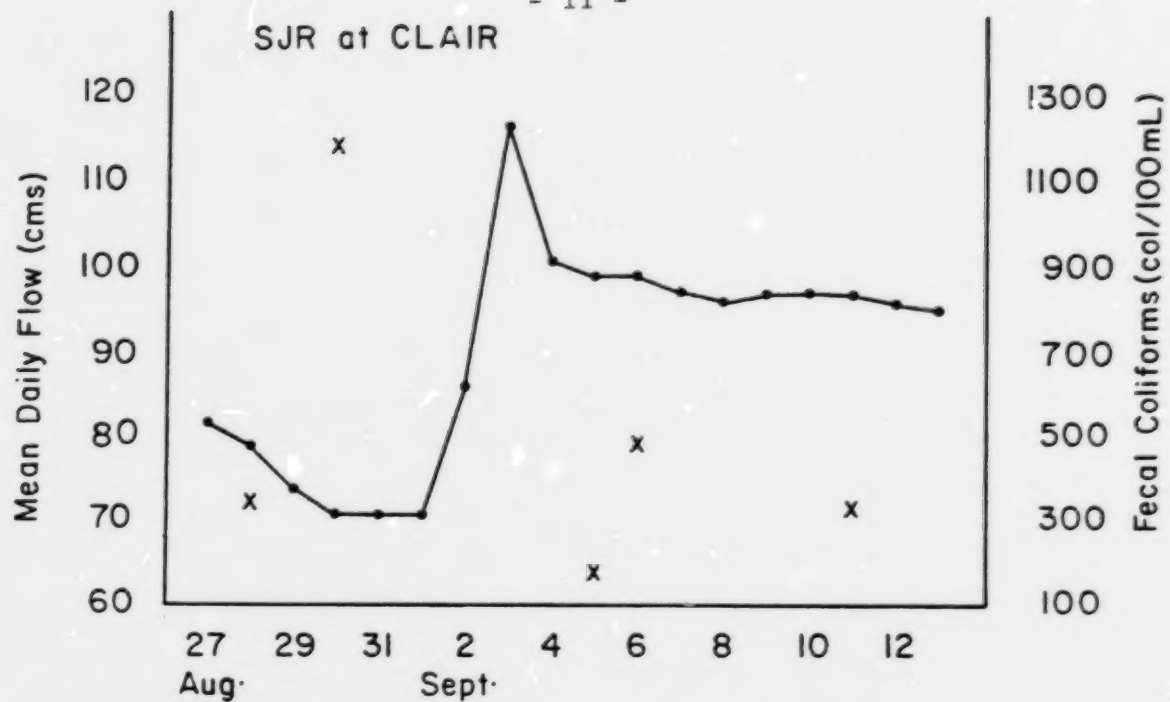


FIGURE 3. FECAL COLIFORMS(X) AND DAILY MEAN FLOW(•)
AT CLAIR AND EDMUNDSTON

approximately 10 km upstream of St. Francois-de-Madawaska and the Saint John River at Grand Falls also exceeded the average water quality objective, however a brief qualification should be made regarding these sites. Little River had a range of values from 96 to 970 colonies/100 mL with a log mean of 220. The value of 970 colonies/100 mL on August 31 coincided with the increasing flow following a rain event overnight. This value has a profound effect on the log mean, although the mean may have been much higher if more samples had been collected during the runoff period of the rain event. This 10-fold increase in the value as the result of a rain event closely parallels the increases experienced at Grand River during the 1982 Survey (2). At Grand Falls, interferences in the fecal coliform analysis were noted in three of the six individual samples. The values of the samples completed were 140 to 750 and had a log mean of 324. Low flows resulting in stagnant water conditions in the Grand Falls headpond was believed responsible for the interferences.

3.2 Fecal Coliform/Fecal Streptococcus Ratio

The FC/FS ratio, which is used to characterize the origins of fecal pollution, was discussed in some detail in the 1983 survey report (3). A brief interpretation of the FC/FS ratio is given in Table 3. The FC/FS ratios for all sites may be found in Appendix 1.

TABLE 3: Interpretation of FC/FS Ratios *

FC/FS	0.7	less than or equal to 0.7 indicates pollution derived from livestock or poultry.
FC/FS	0.7 - 1.0	suggests a predominance of livestock or poultry wastes in mixed pollution.
FC/FS	1 - 2	represents a "gray" area of uncertain interpretation
FC/FS	2 - 4	suggests a predominance of human wastes in mixed pollution.
FC/FS	4.0	greater than or equal to 4 indicates pollution derived from human wastes.

* Field Procedures in Water Microbiology (6)

In Appendix 1, 70 percent of all the samples have ratios less than 0.7 indicating the principal source of bacterial input was of animal origin whereas in 1983, 86 percent of the ratios were below 0.7. This difference probably reflects the closer proximity of 1984 sample sites to urban areas and domestic outfalls such as SJR below Edmundston and Felix Martin Brook, as well as a shift in ratio at three core sites. SJR @ Edmundston and St. Leonard and Madawaska River had ratios above 0.7 on 8 of 12 samplings in 1984 whereas it never exceeded 0.7 on 9 samplings in 1983. The FC/FS ratios for the Saint John River sites which exceeded the water quality objectives indicated varying animal and human inputs. At Clair the ratio was very constant with a range of 0.3 to 0.9 whereas the range at Edmundston varied widely from 0.1 to 4.3. Below Edmundston, ratios of 2.9 to 6.7 indicate the input was strongly human in origin.

Duplicate samples were collected on a single occasion at two sites not on the sample list. They were collected on the Saint John River just

above the Nadeau Abattoir and about 2 km below Nadeau at St. Francois-de-Madawaska. The upper site had a fecal coliform average value of 36 colonies/100 mL, a FS value of 530 and FC/FS ratio of 0.07, whereas below Nadeau the values were 320, 735 and 0.44 respectively. The small increase in FS as compared to the 10-fold in FC would suggest the increase in bacterial input was of human origin. The FC/FS ratio of 0.44 below Nadeau falls within the range at Clair.

These data, although based on a single sampling, would indicate that St. Francois-de-Madawaska, 7 km upstream of Clair, would greatly influence the values at Clair. Non-point source inputs along both sides of the Saint John River would also contribute to the perennial high values at this site.

At Edmundston, the ratios also indicate input of animal origin except on the first sampling where input appears to be of human origin (FC/FS - 4.3). No explanation can be offered for this high ratio. Plates for fecal coliforms were described as excellent and all three dilutions of both duplicates fell within the 95% confidence limits for fecal streptococci.

The FC/FS ratio at the Saint John River site below Edmundston ranged from 2.9 to 6.7 strongly indicating domestic input. As noted previously, domestic sewage was reported at the site at the time of sampling.

The Madawaska River and Saint John River at St. Leonard also

indicated bacterial input of human origin with ratio ranges of 0.8 to 4.0 and 0.9 to 2.3 respectively. The remaining "core" sites at St. Francis, above St. Francois-de-Madawaska, Green and Grand Rivers had ratios indicating relatively low levels of animal input. At Grand Falls, interference in the fecal streptococcus test resulted in no reportable ratios.

An analytical problem with fecal streptococcus during the survey should be considered when interpretation of this parameter or the FC/FS ratio is concerned. Beginning with Sept. 5 samples, small pinhead type colonies displaying characteristics of fecal streptococcus appeared and if they were discernable as colonies under 20X they were counted. The validity of these colonies were questioned as the result of poor precision within duplicate samples. No means of identification of the colonies was available. Later consultation with B. Dutka, NWRI (personal communication) (13) led to the conclusion that they may not have been fecal streptococci. The colonies accounted for 10-50% of counts on some plates. The overall effect on the ratio is minimal. Many ratios were very low and even a large error would not change the interpretation. Some ratios near the 0.7 range may change from solely animal input to a ratio indicating predominance of animal input in mixed pollution. Felix Martin Brook, and Saint John River sites at Edmundston and St. Leonard did not seem to have this problem.

3.3 The Tributaries of the Upper Saint John River Basin

The 1983 Survey report recommended that a number of tributaries

between Clair and the St. Francis River, suspected of carrying the bacterial load from piggery and poultry operations, be surveyed to determine their relative bacterial inputs to the Saint John River and perhaps explain the elevated bacterial counts at Clair during the previous surveys.

The seven tributaries, drainage areas and approximate flow ranges are listed in Table 4. The flows are based on the relative drainage areas and flow values calculated for Grand River during the survey. The range of fecal coliform, fecal streptococcus, FC/FS ratio and arithmetic mean value for each site is summarized in Table 5.

The drainage area of the streams ranged from 13.8 square kilometers for Thompson Brook to 468 sq km for Baker Brook and, with the exception of Little River and Baker Brook, all had calculated flows of less than 1 cms during the survey. The fecal coliforms ranged from an arithmetic mean of 10 colonies/100 mL at Vasseur Brook to 350 colonies/100 mL at Little River while the fecal streptococci ranged from 190 at Felix Martin Brook to 980 colonies/100 mL at Vasseur Brook.

Little River, Mill Stream, Pelletier Brook and Baker Brook were four sites sampled prior to and after a major rain event (20.4 mm) recorded on the morning of August 31. The sites were sampled during a low flow period on August 29 and resampled during the early stage of runoff on August 31. The fecal coliform values at Little River and Mill Stream increased 10-fold with counts at Pelletier Brook and Baker Brook increasing 8 and 6 times respectively (Fig. 4, Appendix 1).

TABLE 4: Drainage Area and Flow Range of Tributary Stations

Station	Drainage Area (km ²)	Flow Range (cms)	Mean (cms)
1. Little River	174.	0.6 - 1.4	0.87
2. Mill Stream	18.	0.05 - 0.13	0.09
3. Vasseur Brook	26.4	0.09 - 0.21	0.14
4. Thompson Brook	13.8	0.04 - 0.11	0.07
5. Pelletier Brook	42.9	0.14 - 0.34	0.22
6. Baker Brook	468.	1.5 - 3.7	2.4
7. Felix Martin Brook	16.6	0.05 - 0.13	0.09

TABLE 5: Data Summary - Tributary Stations

Station	# of dup. Samples	FC Range (Mean)	FS Range (Mean)	FC/FS Ratio (Mean)
1. Little River	4	91 - 970 (350)	260 - 1370 (550)	0.31 - 0.71 (0.56)
2. Mill Stream	4	19 - 270* (120)	220 - 1100 (700)	0.086-0.24 (0.17)
3. Vasser Brook	3	7 - 15 (10)	230 - 2300 (980)	0.006-0.03 (0.02)
4. Thompson Brook	3	16 - 28 (20)	410 - 910 (710)	0.02-0.04 (0.03)
5. Pelletier Brook	4	40 - 390* (160)	140 - 1840 (770)	0.09-0.29 (0.20)
6. Baker Brook	4	30 - 330 (210)	83 - 490 (230)	0.17-1.3 (0.7)
7. Felix Martin Brook	3	40 - 690 (330)	150 - 270 (190)	0.15-4.0 (2.0)

* Interference - one sample

A rainfall of 12.5 mm was recorded at Edmundston on Sept. 4 and Sept. 5 which resulted in observed flows 1.5 to 3 times greater than those on August 29. The sample values obtained on Sept. 5 at high flow showed minimal increases in fecal coliforms compared to the August 28 values at Little River and Mill Stream and no increase at Pelletier and Baker Brooks. This phenomenon was also observed during the 1982 survey at Grand River (2). The initial bacterial impact is expected during the early stages of runoff, in this case probably Sept. 4, however the flows remain high on September 5 as a result of draining headwater areas where little bacterial input is anticipated. Since sampling was not performed during the early stages of runoff, it is believed that the peak bacteriological runoff loading, if it occurred, was missed.

The FC/FS ratios for above sites except Baker Brook indicated the bacterial input was of animal origin (Table 5, Appendix I). The ratios increased slightly at these sites on August 31 (Fig.4) but remained less than 0.7 indicating animal origin. Baker Brook had a ratio of 1.3 on Sept. 12 indicating a mixture of human but predominantly animal input.

Vasseur Brook and Thompson Brook produced the lowest fecal coliform values with means of 10 and 20 colonies/100 mL respectively. The stations were not sampled on August 31, therefore any changes in fecal coliforms with respect to runoff were not recorded. The lack of development within the drainage area suggests that the two streams would not respond as those previously discussed.

Felix Martin Brook reacted very differently with respect to

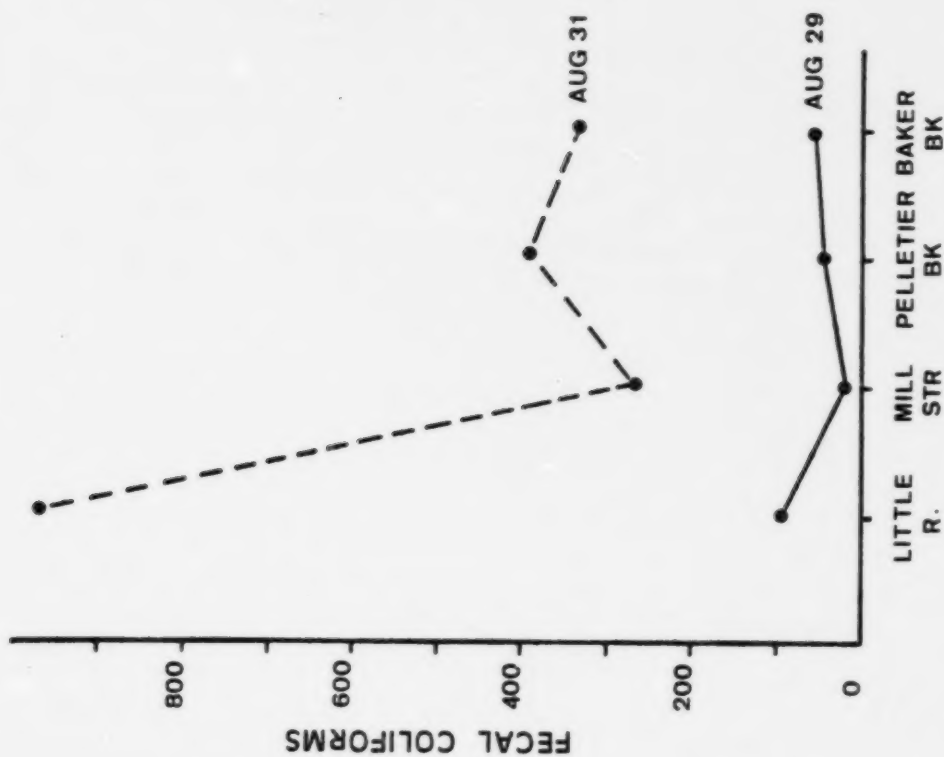
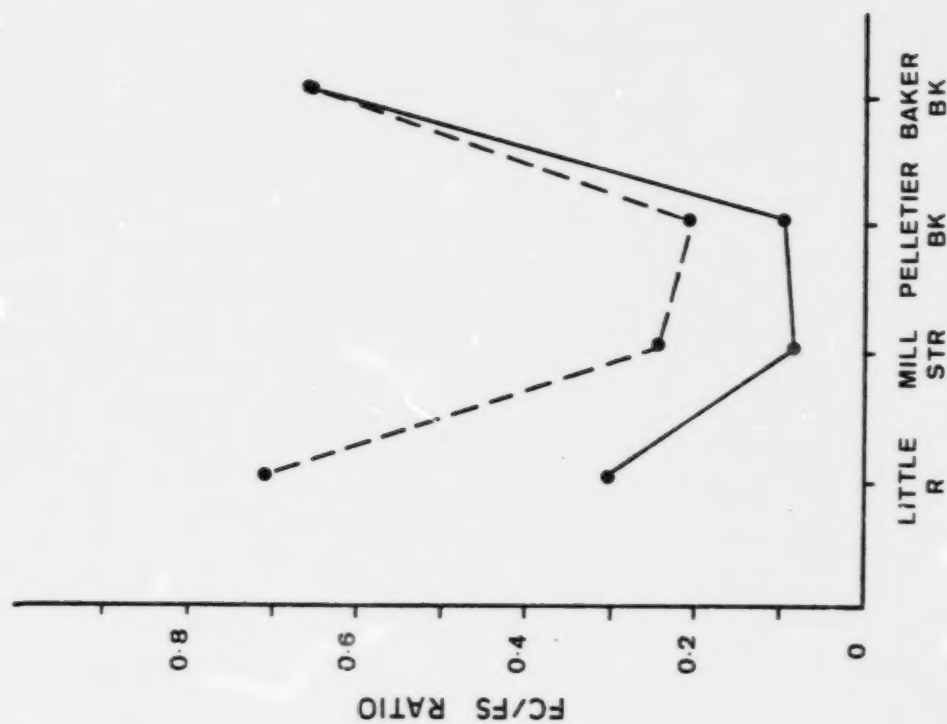


FIGURE 4: FECAL COLIFORMS AND FC/FS RATIOS ON TWO SAMPLING DATES

coliform values, flow and FC/FS ratio as compared to the streams discussed above. The fecal coliform values were high during low flow periods on August 29 (260 colonies/100 mL) and Sept. 12 (690 colonies/100 mL) whereas during high flow on Sept. 5 the value decreased to 40 colonies/100 mL. This is the result of an effluent pipe from the Madawaska Regional Correctional Centre (140 staff and inmates) which empties into this stream approximately 500 m above the sample site. The lower the streamflow, the more impact the effluent has on the stream. The FC/FS ratio was 2.0 on August 31 indicating a mixture of animal and human input while on the lowest flow period (based on Grand River flow values), on Sept. 12, the ratio was 4.0 indicating almost entirely human origin. Bacterial input of animal origin (FC/FS-0.15) was found during the high flow on Sept. 5.

The tributaries surveyed contributed a negligible bacterial load (based on FC values) to the Saint John River during the 1984 survey. Sites above Clair (Little River, Mill Stream, Vasseur Brook) contributed a daily fecal coliform loading of 275×10^9 colonies/day, only 0.7% of the daily loading of 39000×10^9 at Clair (Table 6). The total daily loading by all tributaries was 1.1% as compared to the loading at Edmundston.

TABLE 6: Fecal Coliform Daily Loadings and Export Coefficients

Station	Loading FC/day. (X10 ⁹)	Export Coeff. FC/km ² .day (X10 ⁹)
<u>Tributaries</u>		
1. Little River	264	1.5
2. Mill Stream	9.3	0.5
3. Vasseur Brook	1.2	0.045
4. Thompson Brook	1.2	0.09
5. Pelletier Brook	42.9	0.71
6. Baker Brook	469.	0.9
7. Felix Martin Brook	25.5	1.5
<u>Saint John River</u>		
SJR @ Clair	39,000	3.2
SJR @ Edmundston	77,000	5.0

Baker Brook and Little River contributed the highest loadings (Table 6) with Baker Brook accounting for 58% of the total loading of the tributaries surveyed. Vasseur and Thompson Brooks had the lowest loadings per day. The export coefficient or loading per square kilometer (loading divided by drainage area) indicates that Little River and Felix Martin Brook have the highest loads per unit area. This may be expected due to the development of piggery and poultry operations in the Little River basin and the Correctional Centre on Felix Martin Brook.

3.4 Relationships between Fecal Coliforms and other Water Quality Parameters

The second recommendation of the 1983 survey report (3) was to determine if any relationships existed between bacterial parameters and

selected major ions, nutrients and physical parameters. A study on the Salt River in Arizona (10) determined that there was no correlation between clarity (measured with a Secchi disc or turbidimeter) and fecal coliform counts. A study on the Colorado River (11) on the other hand, observed a positive correlation coefficient(r) of 0.54 between turbidity and fecal coliforms. The authors also referred to a study of the Caddo River in Arkansas where a correlation coefficient of 0.43 was measured between coliform loading and streamflow. This relationship improved to 0.65 when only the rising leg of the storm flow hydrograph was examined. The rising leg more clearly isolates the impact of the more contaminated first flush flows (12).

Tables of the chemical analyses, correlation table for all sites and a correlation for the tributaries are presented in Appendices 2, 3 and 4 respectively. The correlation data summary (Table 7) indicates that there was no strong correlation between fecal coliforms and the other water quality parameters analyzed during the survey.

These correlations are deceptive without further explanation. All sites except the four tributaries sampled August 31 were collected on near peak or falling stream flows, as illustrated in Figure 3 at the Saint John River sites at Clair and Edmundston. If samples had been collected during early run-off stages of the rain events which occurred August 31 and Sept. 4 and 5, the correlation coefficients would probably have increased as a result of the first flush flow phenomenon.

TABLE 7: Summary of Fecal Coliform Correlation Coefficients with other Water Quality Parameters

Parameter	Correlation Coefficient with	
	Mean FC (All sites)	Mean FC (tributaries)
Colour	- 0.04	0.11
Turbidity	0.12	- 0.12
T. Alkalinity	0.16	- 0.04
Calcium	0.16	- 0.19
Magnesium	0.34	0.13
Potassium	0.13	0.19
Sodium	0.15	0.15
pH	0.03	0.06
Chloride	0.08	0.02
Sulphate	0.21	0.06
Silica	- 0.28	0.29
Sp. Conductance	0.19	- 0.05
Diss. Org. Carbon	- 0.01	0.01
Nitrate	0.08	- 0.19
Nitrogen	0.09	- 0.06
Flow - cms	-	- 0.08

This phenomenon, discussed earlier, was well illustrated by events which occurred during the 1982 survey (2). At Grand River, a sample was collected on the early rising flow and resulted in a 40-fold increase in fecal coliform values (38 col/100 mL to 1500 col/100 mL). It was accompanied by increased turbidity due to the

agricultural land use (runoff). The turbidity and flows receded slightly the following day, and the fecal coliform values dropped 4-fold (350 col/100 mL). A second rain event on Day 3 resulted in the fecal coliform values increasing to near levels attained on day one (1100 col/100 mL).

3.5 Summary of Fecal Coliform Data, Compliance and the Water Quality Objectives - 1982 to 1984

Table 8 lists nine sites which have been sampled more than once during the three surveys done 1982, 1983 and 1984.

Saint John River at Clair was the only site which did not meet the average water quality objective for the three years. It exceeded the maximum on 4 occasions in 1982 and once in 1984. The log mean has decreased every year from 1020 in 1982 to 630 in 1983 and 408 in 1984, however it is most probably attributable to the relation with flow (dilution) rather than lower input. With the exception of the second week of the 1982 survey and the one rain event during the third week of the 1984 survey, there was light to minimal runoff during the sample periods.

The average number of colonies (log mean) measured and flow data for 1982 to 1984 are summarized in Table 9.

TABLE 8: Summary of Compliance and the Water Quality Objectives -
1982 to 1984

Station	Year	Min	Max	Log Mean	# of values	Water Quality Objective Met	
		Colonies/100 mL				Max 1000/100mL	Average 200/100mL
1. St Francis R.	1982	3	140	9	6	Yes	Yes
	1983	4	5	5	6	Yes	Yes
2. SJR at St Francis	1983	5	24	12	5	Yes	Yes
	1984	3	11	5	5	Yes	Yes
3. SJR at Clair	1982	590	1325	1020	5	No(4)*	No
	1983	460	740	630	6	Yes	No
	1984	170	1195	408	5	No(1)*	No
4. SJR at Edmundston	1983	45	270	140	4	Yes	Yes
	1984	150	1760	536	5	No(1)*	No
5. Madawaska R.	1983	110	160	140	3	Yes	Yes
	1984	120	190	161	3	Yes	Yes
6. Green R.	1982	21	180	56	6	Yes	Yes
	1983	38	58	50	3	Yes	Yes
	1984	5	9	7	3	Yes	Yes
7. Grand R.	1982	27	1520	177	6	No(2)*	Yes
	1983	79	265	135	5	Yes	Yes
	1984	18	100	35	5	Yes	Yes
8. SJR at St Leonard	1982	18	140	41	4	Yes	Yes
	1983	15	45	21	5	Yes	Yes
	1984	57	280	126	4	Yes	Yes
9. SJR at Grand Falls	1982	88	530	174	6	Yes	Yes
	1983	41	51	47	2	Yes	Yes
	1984	140	750	324	2	Yes	No

* Number of times objective exceeded

TABLE 9: Log Mean versus Flow: Saint John River at Clair 1982-1984

Year	Log Mean colonies/100 mL	Flow Range (cms)	Mean Flow (cms)
1982	1020	37 - 115	58
1983	630	62 - 86	70
1984	408	71 - 117	91

Saint John River at Edmundston, with a log mean number of colonies of 536, showed a 400 percent increase in 1984 compared to 1983. In 1983 the FC/FS ratio ranged from 0.2 to 0.4 for three samples, whereas in 1984 three of five samples fell within this range, the other two samples having ratios of 1.4 and 4.3 indicating human input. The effects of streaming and actual sampling location from the bridge may have contributed to the increase in values.

The Grand River exceeded the maximum objective two times during the 1982 survey where samples were collected on increasing flows after rain events. During the last two years, samples were not collected during or after rain events and much lower values resulted.

The Saint John River site at Grand Falls which exceeded the average water quality objective in 1984 was discussed in the previous section.

4. CONCLUSIONS

Twelve of the seventeen sites monitored during the 1984 survey met both the average and maximum water quality objectives. The Saint John River sites at Clair, Edmundston and below Edmundston exceeded the average water quality objective of 200 colonies/100 mL with values of 408, 536 and 7800 colonies/100 mL respectively. Clair and Edmundston each exceeded the maximum water quality objective of 1000 colonies/100 mL on one occasion, however the site below Edmundston exceeded the maximum on all four samples. Little River and Saint John River at Grand Falls also exceeded the log mean.

The seven tributaries were quite variable in number of fecal coliforms observed. Little River, Mill Stream, Pelletier and Baker Brook display up to 10-fold increases in fecal coliforms during the early run-off stages of a rain event. The overall impact of the tributaries, with respect to total daily loading, was 0.7% and 1.1% when compared to the Saint John River at Clair and Edmundston respectively.

There was no correlation found between fecal coliforms and major ions and nutrients analyzed during the survey. These correlations were biased by falling stream flows and may have been better if more samples had been collected during early run-off stages of the rain events.

The Saint John River at Clair sampling site exceeded the average water quality for all three years of the survey, though the log mean

number of colonies has decreased every year from 1020 in 1982 to 408 in 1984. Greater dilution as a result of higher flows is probably responsible for the decreasing values. Saint John River at Edmundston value increased almost 400 percent from 1983 to 1984. The values at Grand River decreased considerably in 1984 as compared to run-off related high values determined during the 1982 survey.

5. RECOMMENDATIONS

- (1) The Water Quality Branch has conducted three bacteriological surveys from 1982 to 1984 in the international portion of the Saint John River. The surveys were carried in the summer to early fall - the recreational period for the river.

The 1982 survey provided baseline flow as well as showing the dramatic increases in fecal coliform after a runoff producing rain event. During the 1983 and 1984 surveys, rain events did not occur or were missed, resulting in values typical of one regime - low base flow with minimal runoff. Most sites under these conditions have been well below both the average and maximum Water Quality Objectives.

It has been suggested a monitoring format versus the present survey program would maximize the probability of sample collection during all stages of the hydrograph. This long term monitoring program would consist of eight samplings, in conjunction with the present water quality monitoring program, throughout the twelve month period with the probability of three samples collected from June to September.

It is recommended that the ITAS Subcommittee review the two formats with respect to the Water Quality Objectives, interpretability of the data, etc. and then inform the Water Quality Branch, Moncton, whether the survey or monitoring format would be more beneficial to

their needs.

- (2) The fecal coliform values at Clair have exceeded the average Water Quality Objective in each of the past three surveys.

It is recommended a survey be conducted to study the river basin from Clair to St. Francois-de-Madawaska to provide more information on sources of contamination resulting in the perennially high values.

- (3) The study on the tributaries was incomplete. The increase and potential impact of fecal coliform on the rising leg of the flow hydrograph due to rain events was not evaluated especially in areas where piggery waste is sprayed on fields during the summer months.

It is recommended that a survey be conducted to study two small tributaries of the Upper Saint John River Basin which drain areas associated with piggery operation. The study would measure fecal coliform prior, during and after a rain event to help understand the dynamics of the first flush flow phenomenon and duration of values which exceed the Water Quality Objectives.

6. REFERENCES

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APPENDIX I

BACTERIOLOGICAL DATA FOR THE SAINT JOHN RIVER (AUG-SEPT/1984)

STATION LOCATION	SAMPLE DATE	SAMPLE TIME	FECAL COLIFORMS	FECAL COLIFORMS	FECAL STREPT	FECAL STREPT	FC/FS RATIO
1 SJR AT ST. FRANCIS	840828	915	8	14	340	500	0.03
	840830	830	3	3	1100	1020	0.003
	840905	830	10	12	120	380	0.04
	840906	945	0	8	80	60	0.6
	840911	825	1	4	180	430	0.01
2 LITTLE RIVER	840829	830	96	86	260	320	0.3
	840831	815	970	6400*	1370	61000*	0.7
	840905	1100	140	220	300	260	0.6
	840912	820	140	220	240	280	0.7
3 SJR ABOVE ST. FRANCOIS- DE-MADAMASKA	840828	1000	10	10	540	550	0.02
	840830	900	4	2	980	980	0.003
	840905	900	18	6	340	400	0.03
	840906	915	6	4	100	180	0.04
	840911	930	6	18	230	320	0.04
4 MILL STREAM	840828	900	18	20	240	200	0.09
	840831	830	240	300	970	1240	0.2
	840905	1130	100	60	380	500	0.2
	840912	900	INT**	INT	1070	970	-
5 VASSER BROOK	840829	920	10	4	160	300	0.3
	840905	1145	25	5	2240	2280	0.01
	840912	1045	6	12	820	80	0.02
6 SJR AT CLAIR	840828	815	350	340	600	460	0.7
	840830	745	1300	1090	1550	1540	0.1
	840905	745	140	200	550	450	0.3
	840906	745	480	510	1030	920	0.5
	840911	1015	280	370	450	260	0.9
	840913	935	INT	INT	610	470	-
7 THOMPSON BROOK	840829	945	14	18	390	420	0.04
	840905	1201	25	10	770	850	0.02
	840913	955	25	30	900	920	0.03
8 PELLETIER BROOK	840829	1015	50	44	480	560	0.1
	840831	900	390	INT	1890	1780	0.2
	840905	1215	50	30	165	110	0.3
	840913	1020	INT	INT	680	500	-
9 BAKER BROOK	840829	1045	72	38	75	90	0.7
	840831	930	250	410	510	470	0.7
	840905	1230	40	20	190	160	0.2
	840912	1145	180	230	130	180	1.3
10 MICHAUD BROOK	840829	1115	260	260	110	180	1.8
	840905	1255	50	30	260	270	0.2
	840912	1201	800	570	170	170	4.0

* NOT USED IN CALCULATION OF FC/FS RATIO

** INTERFERENCE

APPENDIX I CONT

BACTERIOLOGICAL DATA FOR THE SAINT JOHN RIVER (AUG-SEPT/1984)

STATION LOCATION	SAMPLE DATE	SAMPLE TIME	FECAL COLIFORMS	FECAL COLIFORMS	FECAL STREPT	FECAL STREPT	FC/FS RATIO
11 SJR AT EDMUNDSTON	840828	1205	1760	INT	410	INT	4.3
	840830	1130	500	790	3020	2920	0.2
	840906	1130	940	740	560	660	1.4
	840911	1230	160	140	1850	1620	0.1
	840913	1540	270	350	1460	1400	0.2
12 MADAMASKA RIVER	840829	1345	120	120	130	170	0.8
	840905	1445	195	170	100	110	1.7
	840912	1600	190	190	50	45	4.0
13 SJR BELOW EDMUNDSTON	840828	1235	7400	6500	1080	1000	6.7
	840830	1300	7400	8200	2650	2650	2.9
	840906	1201	6600	9400	2440	1980	3.6
	840911	1310	7890	9600	2520	1830	4.0
14 GREEN RIVER	840829	1430	6	8	260	280	0.03
	840906	1230	8	2	160	100	0.04
	840912	1500	8	10	90	95	0.1
15 GRAND RIVER	840828	1330	20	24	220	150	0.1
	840830	1300	46	58	106	135	0.4
	840905	1545	120	80	140	110	0.8
	840911	1400	22	30	1860	1850	0.01
	840913	1445	18	18	185	160	0.1
16 SJR AT ST. LEONARD	840828	1400	78	36	52	59	1.0
	840830	1330	INT	INT	450	480	-
	840905	1315	INT	280	120	120	2.3
	840911	1435	65	80	100	60	0.9
	840913	1420	220	220	135	230	1.2
17 SJR AT GRAND FALLS	840906	1400	140	INT	INT	INT	-
	840911	1520	620	880	INT	INT	-
	840913	1330	INT	INT	INT	INT	-

APPENDIX II

CHEMICAL ANALYSES DATA

STN LOCATION	CHLORIDE (MG/L)	SULPHATE (MG/L)	SILICA (MG/L)	SP. COND (USIE/CM)	DOC (MG/L)	NO3-DISS (MG/L)	TOTAL N (MG/L)	FTEMP (DEG.C)	MEAN FC (COL/100ML)
1 SJR AT ST. FRANCIS	0.6	4.2	3.5	63	9.2	0.08	0.18	18	11
	0.6	4.5	3.3	61	8.4	0.07	0.16	20	3
	0.9	4.4	3.6	57	11.0	0.05	0.20	15	11
	0.9	4.5	4.0	57	10.0	0.06	0.20	13	4
	0.8	4.8	3.3	59	11.0	0.02	0.13	17	3
2 LITTLE RIVER	0.7	4.0	6.7	78	2.9	0.05	0.10	15	91
	0.7	4.0	6.7	79	3.2	0.06	0.11	16	970
	1.0	3.2	6.8	78	2.5	0.06	0.12	14	180
	1.1	4.5	7.2	79	2.9	0.05	0.11	13	180
3 SJR ABOVE ST. FRANCOIS	0.5	4.1	3.6	63	10.0	0.02	0.11	19	L10
	0.5	4.1	2.5	62	9.7	0.02	0.10	21	3
	0.8	4.0	3.6	57	11.0	0.03	0.16	15	12
	0.8	4.5	4.1	58	11.0	0.04	0.17	14	5
	0.9	5.0	3.5	61	9.8	0.05	0.15	18	5
4 MILL STREAM	1.4	3.2	6.8	105	5.6	0.34	0.45	14	19
	10.6	3.2	6.8	146	5.4	0.27	0.34	15	270
	2.1	3.2	6.5	108	4.3	0.46	0.57	13	80
	2.7	3.5	7.4	120	4.0	1.10	1.10	10	INT
5 VASSEUR BROOK	0.5	3.2	6.0	90	5.4	0.01	0.10	14	7
	0.8	3.2	5.8	91	4.5	0.04	0.10	13	15
	1.0	3.0	5.5	94	3.7	0.01	0.10	12	9
6 SJR AT CLAIR	0.5	4.0	3.7	63	10.0	0.02	0.12	19	345
	0.6	4.1	3.6	63	9.8	0.02	0.13	21	1195
	0.9	4.5	3.7	59	11.0	0.03	0.17	15	170
	0.9	4.5	4.1	59	11.0	0.01	0.13	14	495
	0.9	4.2	3.6	62	8.1	0.04	0.18	18	325
	0.9	4.1	3.6	63	7.5	0.03	0.15	15	INT
7 THOMPSON BROOK	0.5	3.4	6.4	85	3.0	0.06	0.12	15	16
	0.8	3.5	7.0	85	2.4	0.06	0.10	13	18
	0.5	4.1	7.8	86	2.2	0.10	0.14	10	28
8 PELLETIER BROOK	4.2	4.5	6.5	96	2.4	0.21	0.26	15	390
	3.8	2.7	6.5	93	2.4	0.20	0.27	13	40
	3.9	4.2	6.1	96	1.9	0.19	0.23	9	INT
9 BAKER BROOK	2.0	4.1	4.3	100	3.3	0.01	0.10	17	55
	2.0	4.1	4.5	100	3.0	0.01	0.10	17	330
	1.9	4.0	4.7	100	2.4	0.04	0.10	15	30
	1.7	3.8	5.1	103	2.2	0.01	0.10	15	205
10 FELIX MARTIN BROOK	1.2	3.7	6.1	93	3.3	0.06	0.12	17	260
	1.1	3.5	6.4	89	4.0	0.05	0.13	15	40
	0.9	3.7	5.4	101	2.3	0.08	0.15	14	685

APPENDIX 11

CHEMICAL ANALYSES DATA

STN LOCATION	CHLORIDE (MG/L)	SULPHATE (MG/L)	SILICA (MG/L)	SP. COND (USIE/CM)	DOC (MG/L)	NO3-DISS (MG/L)	TOTAL N (MG/L)	FTEMP (DEG C)	MEAN FC (COL/100)
11 SJR AT EDMUNDSTON	2.4	6.0	3.1	123	5.6	0.01	0.11	20	1760
	1.1	4.7	3.3	66	9.3	0.01	0.10	21	645
	1.2	4.5	3.9	63	9.5	0.04	0.20	15	840
	0.9	4.4	3.6	65	7.5	0.02	0.15	18	150
	0.9	4.4	3.6	66	7.1	0.01	0.13	15	310
12 MADAMASKA RIVER	2.0	5.6	2.9	121	5.5	0.08	0.15	20	120
	2.1	5.3	3.1	121	4.9	0.12	0.20	18	180
	1.5	5.2	3.1	121	4.8	0.09	0.16	16	190
13 SJR BELOW EDMUNDSTON	2.3	6.0	3.2	124	6.3	0.01	0.10	21	6950
	2.2	6.0	3.0	124	5.9	0.02	0.10	21	7800
	2.3	5.3	3.3	125	4.8	0.13	0.23	16	8000
	2.0	5.5	3.1	125	5.1	0.15	0.23	19	8700
14 GREEN RIVER	1.0	4.5	5.3	98	2.2	0.06	0.10	22	7
	0.8	4.3	5.5	97	1.7	0.08	0.12	15	5
	0.5	4.1	5.5	99	1.2	0.07	0.12	16	9
15 GRAND RIVER	2.4	4.7	5.1	170	4.6	0.06	0.13	20	22
	2.4	4.7	5.0	180	4.3	0.02	0.10	20	52
	2.3	4.0	5.6	163	4.3	0.04	0.10	18	100
	1.9	4.2	5.3	180	3.7	0.01	0.10	19	26
	2.0	4.4	5.2	183	3.1	0.01	0.10	16	18
16 SJR AT ST. LEONARD	2.8	8.5	3.6	93	8.8	0.01	0.13	21	57
	2.3	8.0	3.5	100	7.5	0.01	0.10	21	INT
	2.7	7.3	4.0	96	8.0	0.10	0.22	16	280
	2.8	8.2	3.5	101	7.5	0.07	0.12	19	72
	3.1	8.5	3.3	105	7.4	0.02	0.12	16	220
17 SJR AT GRAND FALLS	2.3	7.0	3.9	97	6.7	0.01	0.10	17	140
	3.0	8.0	3.5	103	8.5	0.05	0.16	18	750
	2.8	8.4	3.5	104	7.7	0.10	0.20	16	INT

APPENDIX II

CHEMICAL ANALYSES DATA

STN LOCATION	DATE	TIME	COLOUR (REL.UN.)	CALCIUM (MG/L)	T. ALKAL (MG/L)	TURBIDITY (JTU)	MAGNESIUM (MG/L)	POTASSIUM (MG/L)	SODIUM (MG/L)	PH (UN.)
1 SJR AT ST. FRANCIS	840828	915	40	9.4	22.8	0.3	1.3	0.35	1.2	7.4
	840830	830	35	9.4	21.4	0.4	1.3	0.40	1.2	7.3
	840905	830	65	8.8	19.3	0.5	1.3	0.40	1.2	7.4
	840906	845	60	9.2	20.1	0.5	1.3	0.40	1.1	7.4
	840911	825	5	9.1	20.9	0.3	1.3	0.35	1.2	7.1
2 LITTLE RIVER	840829	830	5	12.0	31.0	0.3	1.4	0.35	1.9	7.4
	840831	815	5	12.0	31.5	0.8	1.4	0.35	1.8	7.5
	840905	1100	5	12.0	31.3	0.4	1.5	0.40	1.9	7.5
	840912	820	40	12.0	32.3	0.5	1.5	0.30	1.8	7.5
3 SJR ABOVE ST. FRANCIS DE-MADAMASKA	840828	1000	40	9.8	22.5	0.4	1.2	0.35	1.2	7.4
	840830	900	40	9.8	22.6	0.4	1.2	0.35	1.2	7.4
	840905	900	70	8.9	20.1	0.6	1.3	0.35	1.2	7.3
	840906	915	60	9.2	20.3	0.7	1.3	0.35	1.1	7.4
	840911	930	30	9.4	22.3	0.5	1.3	0.35	1.2	7.5
4 MILL STREAM	840829	900	20	16.0	41.4	0.5	1.7	0.75	2.5	7.6
	840831	830	15	22.0	42.3	1.2	2.0	0.85	2.7	7.6
	840905	1130	15	16.0	43.1	0.6	1.8	0.75	2.4	7.8
	840912	900	10	18.0	44.9	0.4	1.9	1.00	2.8	7.5
5 VASSEUR BROOK	840829	920	25	15.0	39.3	0.6	1.7	0.25	1.7	7.7
	840905	1145	20	14.0	39.4	0.7	1.8	0.25	1.6	7.8
	840912	1045	10	15.0	41.0	0.6	1.3	0.28	1.7	7.8
6 SJR AT CLAIR	840828	815	40	10.0	23.3	0.6	1.2	0.35	1.2	7.4
	840830	745	35	10.0	23.0	0.4	1.3	0.35	1.3	7.5
	840905	745	65	9.4	21.8	0.6	1.3	0.35	1.2	7.4
	840906	745	60	8.9	21.8	0.4	1.3	0.40	1.2	7.3
	840911	1015	35	9.6	22.7	0.5	1.4	0.32	1.0	7.5
	840913	935	35	9.8	22.9	0.5	1.3	0.38	1.2	7.5
7 THOMPSON BROOK	840829	945	5	13.0	36.1	0.5	1.4	0.30	1.7	7.6
	840905	1201	5	13.0	35.9	0.4	1.4	0.35	1.9	7.5
	840913	955	5	14.0	35.2	0.3	1.5	0.32	1.7	7.4
8 PELLETIER BROOK	840829	1015	5	13.0	33.0	0.6	1.8	0.50	3.5	7.5
	840831	900	5	13.0	33.6	0.8	1.9	0.50	3.5	7.6
	840905	1215	5	12.0	33.5	0.7	1.8	0.50	3.4	7.8
	840913	1020	5	13.0	33.5	0.7	1.9	0.50	3.2	7.9
9 BAKER BROOK	840829	1045	5	15.0	40.8	0.9	1.9	0.40	2.3	7.6
	840831	930	5	15.0	41.2	2.5	1.9	0.40	2.3	7.7
	840905	1230	5	15.0	41.6	1.7	2.0	0.35	2.1	7.7
	840912	1145	5	16.0	42.5	1.5	2.0	0.45	2.2	7.7
10 FELIX MARTIN BROOK	840829	1115	5	13.0	38.7	0.3	2.1	0.50	2.0	7.8
	840905	1255	10	13.0	38.3	0.7	2.0	0.55	2.0	7.8
	840912	1201	5	15.0	42.9	0.4	2.3	0.62	2.3	7.9

APPENDIX II

CHEMICAL ANALYSES DATA

STN LOCATION	DATE	TIME	COLOUR (REL. UN.)	CALCIUM (MG/L)	T. ALKAL (MG/L)	TURBIDITY (JTU)	MAGNESIUM (MG/L)	POTASSIUM (MG/L)	SODIUM (MG/L)	PH (UN.)
11 SJR AT EDMUNDSTON	840828	1201	10	19.0	50.1	0.6	2.4	0.50	2.3	7.6
	840830	1130	25	10.0	24.4	0.5	1.3	0.40	1.6	7.4
	840906	1100	50	9.7	22.2	0.7	1.3	0.40	1.4	7.4
	840911	1230	30	10.0	23.6	0.6	1.4	0.38	1.2	7.6
	840913	1540	30	10.0	23.8	0.5	1.4	0.40	1.3	7.5
12 MADAWASKA RIVER	840829	1345	15	19.0	50.3	0.7	2.3	0.50	2.3	7.9
	840905	1445	15	29.0	50.3	0.8	2.3	0.50	2.2	7.7
	840912	1600	15	20.0	50.6	0.7	2.3	0.50	2.1	7.8
13 SJR BELOW EDMUNDSTON	840828	1235		19.0	50.7	0.7	2.4	0.50	2.6	7.5
	840830	1300	15	19.0	50.5	0.7	2.4	0.50	2.4	7.6
	840906	1201	20	19.0	50.0	1.1	2.3	0.50	2.4	7.7
	840911	1310	20	20.0	51.0	1.0	2.3	0.50	2.3	7.7
14 GREEN RIVER	840829	1430	5	15.0	42.4	0.3	2.2	0.35	1.7	7.8
	840906	1230	5	15.0	41.9	0.3	2.1	0.25	1.7	7.9
	840912	1500	5	15.0	42.0	0.5	2.1	0.55	2.0	7.9
15 GRAND RIVER	840828	1330	5	30.0	76.4	1.6	1.9	0.50	2.4	8.0
	840830	1300	30	32.0	80.6	0.7	1.2	0.40	2.4	8.0
	840905	1545	65	9.5	74.2	1.1	2.0	0.40	2.3	8.1
	840911	1400	5	32.0	80.4	0.6	2.1	0.50	2.3	8.1
	840913	1445	5	32.0	83.2	0.7	2.1	0.55	2.6	8.1
16 SJR AT ST. LEONARD	840828	1400	25	13.0	29.8	1.0	1.9	0.50	3.0	7.3
	840830	1330	30	14.0	34.3	1.2	2.1	0.50	2.4	7.4
	840906	1315	40	14.0	32.7	1.5	2.1	0.50	2.7	7.5
	840911	1435	35	14.0	34.6	1.5	2.4	0.55	2.6	7.5
	840913	1420	35	15.0	35.5	1.8	2.4	0.55	2.6	7.6
SJR AT GRAND FALLS	840906	1400	25	14.0	34.4	0.9	2.0	0.50	2.2	7.5
	840911	1520	35	15.0	35.1	1.5	2.3	0.68	2.7	7.4
	840913	1330	35	15.0	35.8	1.4	2.4	0.62	2.8	7.5

APPENDIX III

CORRELATIONS OF FECAL COLIFORM VERSUS MAJOR IONS AND NUTRIENTS

	COLOUR	CALCIUM	T. ALKAL	TURBIDITY	MAGNESIUM	POTASSIUM	SODIUM	PH	CHLORIDE
COLOUR	1.000000	-0.414333	-0.352920	-0.075029	-0.394320	-0.172164	-0.468500	-0.372204	-0.160987
CALCIUM	-0.414333	1.000000	0.870248	0.281745	0.501357	0.383202	0.481273	0.667879	0.352835
T. ALKAL	-0.352920	0.870248	1.000000	0.301157	0.540353	0.299928	0.513481	0.847665	0.267632
TURBIDITY	-0.075029	0.281745	0.301157	1.000000	0.479884	0.301166	0.462306	0.201146	0.444098
MAGNESIUM	-0.394320	0.501357	0.540353	0.479884	1.000000	0.548332	0.663639	0.541125	0.414061
POTASSIUM	-0.172164	0.383202	0.299928	0.301166	0.548332	1.000000	0.621550	0.225502	0.648250
SODIUM	-0.468500	0.481273	0.513481	0.462306	0.663639	0.621550	1.000000	0.409920	0.676710
PH	-0.372204	0.667879	0.847665	0.201146	0.541125	0.225502	0.409920	1.000000	0.152017
CHLORIDE	-0.160987	0.352835	0.267632	0.444098	0.414061	0.648250	0.676710	0.152017	1.000000
SULPHATE	0.223387	0.095242	0.001035	0.401937	0.416421	0.226194	0.258985	-0.221834	0.173334
SILICA	-0.472328	0.083158	0.205649	-0.140171	-0.013901	0.075557	0.335790	0.269728	0.170079
SP. COND	-0.339949	0.886019	0.970619	0.388970	0.608415	0.455521	0.628103	0.786207	0.474098
DOC	0.770858	-0.416115	-0.542285	-0.135478	-0.471082	-0.115258	-0.548932	-0.633008	-0.171092
NITRATE	-0.210934	0.117785	0.071303	-0.041693	0.193974	0.624890	0.435164	0.121467	0.442237
TOTAL N	-0.002377	0.040352	-0.046262	-0.044907	0.069806	0.627874	0.294200	-0.000820	0.385306
MEAN FC	-0.034663	0.161875	0.160999	0.121792	0.336891	0.132186	0.147138	0.031069	0.082995

	SULPHATE	SILICA	SP. COND	DOC	NITRATE	TOTAL N	MEAN FC
COLOUR	0.223387	-0.472328	-0.339949	0.770858	-0.210934	-0.002377	-0.034663
CALCIUM	0.095242	0.083158	0.886019	-0.416115	0.117785	0.040352	0.161875
T. ALKAL	0.001035	0.205649	0.970619	-0.542285	0.071303	-0.046262	0.160999
TURBIDITY	0.401937	-0.140171	0.388970	-0.135478	-0.041693	-0.044907	0.121792
MAGNESIUM	0.416421	-0.013901	0.608415	-0.471082	0.193974	0.069806	0.336891
POTASSIUM	0.226194	0.075557	0.455521	-0.115258	0.624890	0.627874	0.132186
SODIUM	0.258985	0.335790	0.628103	-0.548932	0.435164	0.294200	0.147138
PH	-0.221834	0.269728	0.786207	-0.633008	0.121467	-0.000820	0.031069
CHLORIDE	0.173334	0.170079	0.474098	-0.171092	0.442237	0.385306	0.082995
SULPHATE	1.000000	-0.542162	0.106230	0.321203	-0.229505	-0.177522	0.208550
SILICA	-0.542162	1.000000	0.182360	-0.703587	0.394129	0.198099	-0.274780
SP. COND	0.106230	0.182360	1.000000	-0.498989	0.165338	0.054207	0.188363
DOC	0.321203	-0.703587	-0.498989	1.000000	-0.246023	0.012022	-0.013548
NITRATE	-0.229505	0.394129	0.165338	-0.246023	1.000000	0.942913	0.081491
TOTAL N	-0.177522	0.198099	0.054207	0.012022	0.942913	1.000000	0.088580
MEAN FC	0.208550	-0.274780	0.188363	-0.013548	0.081491	0.088580	1.000000

APPENDIX IV CORRELATIONS OF FECAL COLIFORM VERSUS MAJOR IONS AND NUTRIENTS - TRIBUTARIES ONLY

	FLOW-CMS	COLOUR	CALCIUM	T. ALKAL	TURBIDITY	MAGNESIUM	POTASSIUM	SODIUM	PH
FLOW-CMS	1.000000	-0.248786	0.045205	0.173291	0.765330	0.181051	-0.233603	-0.043938	-0.073003
COLOUR	-0.248786	1.000000	0.138460	0.059853	-0.151079	-0.130803	-0.021479	-0.235005	0.017690
CALCIUM	0.045205	0.138460	1.000000	0.751059	0.384040	0.401919	0.584126	0.112733	0.232330
T. ALKAL	0.173291	0.059853	0.751059	1.000000	0.418736	0.573026	0.398260	-0.071577	0.661958
TURBIDITY	0.765330	-0.151079	0.384040	0.418736	1.000000	0.366268	0.035522	0.157579	0.192587
MAGNESIUM	0.181051	-0.130803	0.401919	0.573026	0.366268	1.000000	0.526260	0.413809	0.609151
POTASSIUM	-0.233603	-0.021479	0.584126	0.398260	0.035522	0.526260	1.000000	0.546691	0.240281
SODIUM	-0.043938	-0.235005	0.112733	-0.071577	0.157579	0.413809	0.546691	1.000000	0.064216
PH	-0.073003	0.017690	0.232330	0.661958	0.192587	0.609151	0.240281	0.064216	1.000000
CHLORIDE	-0.064112	-0.012728	0.643841	0.145305	0.282120	0.354002	0.620612	0.644108	-0.016073
SULPHATE	0.382360	-0.074366	-0.258710	-0.307832	0.187514	0.082611	-0.205403	0.155485	-0.475909
SILICA	-0.714740	0.234359	-0.234105	-0.610153	-0.652879	-0.476684	0.128666	0.044925	-0.538902
SP. COND	0.022771	0.033862	0.937202	0.688896	0.402671	0.562063	0.740101	0.400802	0.318266
DOC	-0.297743	0.553856	0.550572	0.419306	-0.045218	0.041796	0.358412	-0.135175	0.219817
NITRATE	-0.399448	0.135774	0.358427	0.149694	-0.159766	0.136415	0.789982	0.548137	0.050125
TOTAL N	-0.348903	0.171683	0.412876	0.253680	-0.102458	0.172015	0.806456	0.519439	0.133101
MEAN FC	0.105707	-0.194353	-0.042860	-0.115923	0.128848	0.187678	0.149367	0.059261	0.020836

	CHLORIDE	SULPHATE	SILICA	SP. COND	DOC	NITRATE	TOTAL N	MEAN FC
FLOW-CMS	-0.064112	0.382360	-0.714740	0.022771	-0.297743	-0.399448	-0.348903	0.105707
COLOUR	-0.012728	-0.074366	0.234359	0.033862	0.553856	0.135774	0.171683	-0.194353
CALCIUM	0.643841	-0.258710	-0.234105	0.937202	0.550572	0.358427	0.412876	-0.042860
T. ALKAL	0.145305	-0.307832	-0.610153	0.688896	0.419306	0.149694	0.253680	-0.115923
TURBIDITY	0.282120	0.187514	-0.652879	0.402671	-0.045218	-0.159766	-0.102458	0.128848
MAGNESIUM	0.354002	0.082611	-0.476684	0.562063	0.041796	0.136415	0.172015	0.187678
POTASSIUM	0.620612	-0.205403	0.128666	0.740101	0.358412	0.789982	0.806456	0.149367
SODIUM	0.644108	0.155485	0.044925	0.400802	-0.135175	0.548137	0.519439	0.059261
PH	-0.016073	-0.475909	-0.538902	0.318266	0.219817	0.050125	0.133101	0.020836
CHLORIDE	1.000000	-0.038079	0.091034	0.801341	0.237533	0.473540	0.445523	0.055402
SULPHATE	-0.038079	1.000000	-0.028119	-0.219672	-0.483811	-0.229482	-0.282606	0.294140
SILICA	0.091034	-0.028119	1.000000	-0.227219	0.050057	0.401707	0.302989	-0.050705
SP. COND	0.801341	-0.219672	-0.227219	1.000000	0.455616	0.498270	0.536645	0.009211
DOC	0.237533	-0.483811	0.050057	0.455616	1.000000	0.362785	0.432030	-0.194441
NITRATE	0.473540	-0.229482	0.401707	0.498270	0.362785	1.000000	0.987942	-0.056227
TOTAL N	0.445523	-0.282606	0.302989	0.536645	0.432030	0.987942	1.000000	-0.082712
MEAN FC	0.055402	0.294140	-0.050705	0.009211	-0.194441	-0.056227	-0.082712	1.000000

APPENDIX V

FLOW DATA DURING BACTERIOLOGICAL SURVEY(CMS)

DATE	SJR AT CLAIR*	SJR AT EDMUNDSTON**	GRAND RIVER
AUGUST 25	93	141	
26	89	135	
27	82	125	
28	79	119	1.65
29	74	112	1.57
30	71	105	1.54
31	71	105	1.88
SEPTEMBER 1	71	104	2.39
2	86	118	2.65
3	117	150	2.18
4	101	132	1.84
5	98	128	1.80
6	88	125	2.06
7	97	123	1.70
8	96	121	1.51
9	97	121	1.38
10	97	121	1.30
11	97	120	1.21
12	96	118	1.13
13	95	116	1.09

* SJR AT FORT KENT MINUS FISH RIVER

** SJR AT FORT KENT PLUS 5% (INCREASE IN DRAINAGE AREA)